LESSON 19 – AN INTRODUCTION TO ELECTRONIC WARFARE
(Pick up Problem Set 3)
The adversary you can't find is the hardest one to fight!

Reading:
Stimson **Ch. 1-2**, Ch. 3
Shaw **pp. 40 (last paragraph) to 43**
Problems/Questions:
None
Objectives:
18-1 Know the definition of electronic warfare.
18-2 Know the primary portion of the electromagnetic spectrum used for aerial combat and how it's used.
18-3 Understand the basics of radar operations.
18-4 Know the basics components of a radar and how they work.

Last Time: GR Debrief

Today: Electronic Warfare Overview
What is a Radar?
Angle and Range Information
Basic Components

So far we've discussed visual fighting. But we always assumed that a bandit just appeared, conveniently aligned, right at your 12 o'clock (or maybe your six). How did that magical occurrence happen? We needed to do some maneuvering PRIOR to acquiring the visual. This means we need to be adept in using (and understanding) the on-board sensors, including a variety of components such as radar, RHAW, and IRSTS.

As you saw last block, these long range maneuvers whose purpose is to bring you to the merge with as much positional advantage and situational awareness as possible are called intercepts, and the tactics involved in intercepts are extremely dependent upon a solid knowledge of the strengths and weaknesses of not only your airframe and sensors, but of the similar attributes of the enemy's weapons systems.

What is Electronic Warfare?

Electronic warfare is controlling and using the Electromagnetic Spectrum to "win the fight", while denying the enemy that control and use.

There are three general missions of EW, which used to be called: electronic support measures (**ESM**), electronic countermeasures (**ECM**) and electronic counter-countermeasures (**ECCM**). Although these terms are dated, we'll continue to use them in this class, since they're descriptive

ESM – Actions taken to search for, intercept, and identify and locate sources of radiated EM energy for the purpose of immediate threat recognition. (RC-135, EC-130, U-2R, JSTARS, satellites and any aircraft with a Radar Warning Receiver [RWR]).

ECM – Actions taken to prevent or reduce an enemy's effective use of the EM spectrum, primarily through jamming and deception (EC–130, EA–6B, F-16CJ)

ECCM – actions taken to attempt to retain use of EM equipment despite the opposing force's use of EW.

Show F-22 Air Dominance Imperative (about 10 Min)

Administer Mid-course Critiques

What is RADAR (RAdio Detection And Ranging)?

The microwave portion of the electromagnetic spectrum (wavelengths around 3 cm) is the primary segment used for air combat.

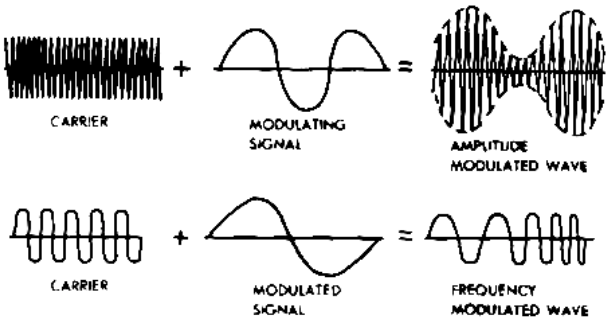
Why microwaves? The atmosphere (as long as weather is not too heavy) is relatively transparent to microwaves. We can also focus microwaves into a tight but not too tight beam balanced for resolution and search efficiency

Shorter wavelengths (millimeter and below) have poorer range (large atmospheric attenuation), and longer wavelengths require more massive generation equipment and have poor resolution.

How does a radar work?

Radar sends a modulated EM wave to a target. The radio energy reflects off the target, and we can extract information from the returning signal. Modulation is the act of altering the amplitude, frequency, phase, or duration of an EM wave. There are two main types of EM wave modulation:

Continuous Wave and Pulse. A **continuous wave (CW) radar** sends a continuous EM wave towards the target, with modulations in the EM wave's frequency and/or amplitude over time. A **pulsed radar** modulates the EM wave by switching the EM wave on and off continuously. Thus, creating pulses of the EM wave.



What sort of information can we get from the reflected wave? Range and Angle!

Angular Information

Show flashlight demo. Have a volunteer stand up somewhere in the room. Turn off the room's light and use a flashlight to locate the person. Comment on how you would describe the person's location to somebody who is not in the room.

Since radars are designed to send the EM waves in a certain direction, the angular position of the target can be found by correlating the target's position with the direction the radar is pointing.

Now have someone try to find a small model aircraft on the front wall using a flashlight and a laser pointer. Which one would you rather have? Why? Discuss balance between angular resolution and speed of search.

Range Information

Perform Marching demo. This demonstrates a pulse radar technique. Find three volunteers. One to be the radar, one to be the radar's pulse and another to be the target. Have the radar start a stopwatch and at the same time send the pulse to the target by having the pulse march to the target at a standard cadence. Once the pulse reaches the target, the target sends the pulse back to the radar at a standard cadence. When the pulse returns to the radar, the radar will stop the stopwatch. Comment on finding the distance to the target. This is called "Pulse-delay ranging". There are other types of ranging that we'll discuss in future lessons.

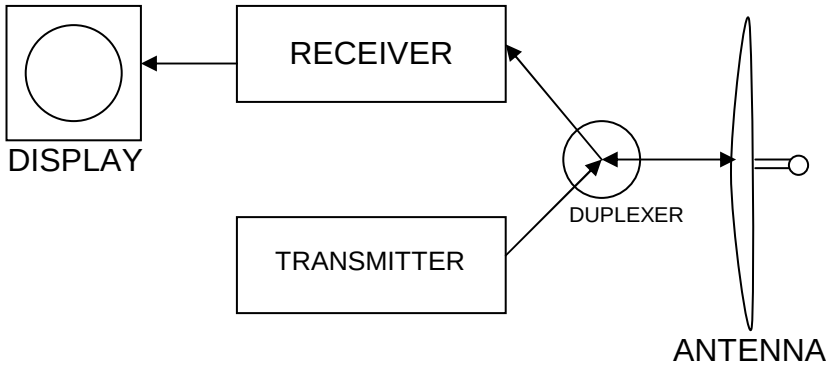
Range is found by using the fact that all EM waves travel at the speed of light. Thus by timing how long it takes for pulse or wave modulation to return, a distance can be found.

For a radar the range to the target can be found by

$$\boxed{R = \frac{ct}{2}}$$

Where R is the range to the target, c = 3×10^8 m/s (the speed of light) and t is the total round trip time.

Basic Components of a Radar



The antenna focuses the EM energy from the transmitter in a relatively narrow beam and collects the EM energy from returns within the same narrow beam the energy was sent out in. We'll discuss how the focusing happens in a later lesson. The antenna also steers the beam.

The transmitter produces the high powered, modulated EM wave.

The receiver detects and amplifies the weak returns from the transmitted signal. Also, it puts the detected returns in a useable form for the display or instrumentation used to process the returns.

The display presents the returns from the receiver in a method that the radar user can quickly interpret.

A duplexer is used only when the transmitter and receiver use the same antenna. Performs time-sharing between transmitter and receiver.